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# EFFECT OF MYCORRHIZA INOCULATION AND FOLIAR SPRAY OF SOME PLANTS EXTRACTS ON FENNEL GROWTH AND PRODUCTIVITY

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## ABSTRACT

This experiment was conducted during 2013- 2014 and 2014 – 2015 seasons at the Experimental Farm, Fac. of Environ. Agric. Sci., El-Arish, Suez Canal Univ., Egypt, to study the effect of mycorrhiza inoculation (AM) and foliar spray of some plants aqueous extracts (*Glycyrrhiza glabra* L. and *Moringa oleifera* M.) on fennel (*Foeniculum vulgare* Mill) growth and productivity. The applied concentrations of licorice root extract were control (distilled water), 20 $gl^{-1}$ (L1), 40 $gl^{-1}$ (L2) and 60 $gl^{-1}$ (L3), while moringa leaves extract concentrations were control (distilled water), 20 $gl^{-1}$ (M1), 40 $gl^{-1}$ (M2) and 60 $gl^{-1}$ (M3). Both aqueous extracts were applied twice (the first was after one month of cultivation and the second one was after two weeks from the first one). The obtained results showed that inoculated fennel plants with mycorrhiza Fungi and sprayed with L2 (40 $gl^{-1}$) or L3 (60 $gl^{-1}$) aqueous extract of licorice roots recorded the highest significant values of all growth and flowering parameters without significant difference between both treatments in most cases in the first season. The same trend was observed in the second season, but only inoculated plants which were sprayed with 60 $gl^{-1}$ licorice extract gave the highest significant growth and flowering values, *i.e.*, plant height, branch number, herb fresh and dry weights, number of umbels per plant and number of umbellets per umbel (100.03 cm, 9.70, 67.74 g, 24.88 g, 10.66 and 11.33, respectively). Moreover, fennel plants inoculated with AM Fungi combined with spraying (60 $gl^{-1}$) aqueous extract of licorice roots (L3) resulted in a significant increase of fruit No./umbel, fruit yield/plant and fruit yield/fad. (12.66, 17.51g and 490.28 kg, respectively) during the first season and 13.00, 18.46 g and 516.88 kg, respectively in the second season. On the other hand, fennel plants inoculated with AM Fungi combined with aqueous extract foliar spray of moringa leaves (M3) gave the highest herb contents of nitrogen (0.374 and 0.385 ppm), phosphorus (0.275 and 0.283 ppm) and potassium (148.49 ppm and 156.13 ppm) in both seasons, respectively.

**Key words:** Fennel, licorice, moringa, arbuscular mycorrhizal fungi (AMF).

## INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) which belongs to family Umbelliferae (Apiaceae) is an annual plant. Vegetative parts of the plant are used as a green salad while fruits have a pleasant, spicy odour and burning sweet taste. It has pharmaceutical, perfumery and food flavoring used.

Fennel fruits contain 1-3% volatile oil, which has disinfectant and anti-inflammatory action, primarily on the respiratory and digestive organs and has an antispasmodic effect on smooth muscle (Stary and Jirasck, 1975). Also, essential oil of fennel is used as flavoring agent in food products such as beverages, bread, pickles, pastries, and cheese. It is also used as a constituent of cosmetic and pharmaceutical products (Piccaglia and Marotti, 2001).

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Antioxidant and antimicrobial activity of fennel has also been reported (Ruberto *et al.,* 2000).

Mycorrhizal fungi are beneficial microorganisms and have been considered as bio-fertilizer. It is an obligate group (Javaid, 2007; Javaid *et al.*, 2007; Javaid and Riaz, 2008) found in more than 80 % of land plant families (Smith and Read, 2008). In this association, the fungus is supplied with soluble carbon sources (photosynthesis) by the host plants, whereas the fungus provides the host plant with a better ability to take up water and nutrients from the soil (Entry *et al.,* 2002; Javaid, 2009). Arbuscular Mycorrhizal Fungi (AMF) can also benefit plants by stimulating the production of growth regulating substances, improving osmotic adjustment under drought and salinity stresses and increasing resistance to pests and soil borne diseases (Al-Karaki, 2006). These benefits are mainly attributed to improve phosphorous nutrition (Plenchette *et al.,* 2005). Most horticultural and crop plants establish the symbiosis with AMF. Although the mycorrhizal potential of the symbiosis to improve horticultural production is recognized (Estaun *et al*., 2002) it has not been implemented under field conditions.

AM fungi are important components of virtually all terrestrial ecosystems and are especially critical in improving plant nutrient and water uptake under semi-arid conditions (Van der Heijden *et al*., 2006; Allen, 2011). Most terrestrial ecosystems depend on mycorrhiza, which promote the establishment, growth and health of plants. Improved plants productivity by AM fungi was attributed to enhanced uptake of immobile nutrients such as phosphorus, zinc, nitrogen and copper. AM fungi can be integrated in soil management to achieve low-cost sustainable agricultural systems (Hooker and Blackke, 1995). Resistance against biotic (Khaosaad *et al.,* 2007) and abiotic stresses (Auge, 2001; Javaid, 2007; Azcón *et al.,* 2009) has been argued to be due to the effects of AM fungi on inducing plant hormones production. Phosphate solubilizing microorganisms are another sort of bio-fertilizers which have the ability to solubilize organic and inorganic phosphorus compounds by producing organic acid or phosphatase enzyme.

*Glycyrrhiza glabra* roots are rich in many essential minerals, flavonoids and natural antioxidants (Morsi *et al.,* 2008). In addition, licorice extract contains protein and amino acid (Asparagin), monosaccharides (glucose, fructose, sucrose and maltose), lignins, tannins, starch, choline, phytosterols, different types of vitamins such as B1, B2, B3, B6, C, E, biotin, folic acid, pantothenic acid, many mineral nutrients (aluminum, calcium, iron, magnesium, cobalt, zinc, phosphorus, sodium, silicone, potassium and stannous) and bitter principles (Rossi, 1999; Arystanova *et al.*, 2001). Foliar spraying with licorice extract has a favorable biological effect on fresh and dry weights of plants, flowering, total yield and fruits quality for several crops; *viz.*, sweet pepper (El-Jawary, 2002), cucumber (Fayad, 2005; Jibouri *et al.,* 2005; Husain and El-Rekaby, 2006), bean (Kamal and Ghanem, 2012), fenugreek (Nasser *et al.*, 2014) and roselle (Hassan and Abd El-Samee, 2015).

Moringa (*Moringa oleifera* L.) belongs to Moringaceae family. Moringa leaf extract is a rich source of amino acids, potassium, calcium, iron, vitamin E, ascorbates, phenolic compounds and growth regulating hormones like zeatin (Makkar and Becker, 1996 and Nagar *et al*., 2006). Thus it possesses the potential to promote plant growth, hence it can be used as a natural plant growth permoter. Zeatin is the most naturally occurring cytokinin that not only promotes the growth of plants by facilitating cell division and cell elongation as well as its anti-aging potential and protective effects in plants.

Moringa leaf extract has been reported to increase the yield of many crops *viz*; major cereals [maize (*Zea mays* L.), rice (*Oryzae*

*sativa* L.), sorghum (*Sorghum bicolor* L.)]; wheat (*Triticum sativum* L.) as reported by Phiri (2010) and Abbas *et al.* (2013), tomato (Culver *et al*., 2012), common bean (*Phaseolus vulgaris* L.) (Rady and Mohamed, 2015) and roselle (Hassan and Abd El-Samee, 2015).

This trial aimed to improve growth and productivity of fennel by using mycorrhiza incoculation and foliar spray with aqueous extracts of some medicinal plants (*Glycyrrhiza glabra* and *Moringa oleifera*) under North Sinai conditions.

## MATERIALS AND METHODS

Field experiment was carried out at the Experimental Farm, Faculty of Environmental Agricultural Sciences, El-Arish, North Sinai Governorate during two successive winter seasons of 2013/2014 and 2014/2015, to study the effect of two foliar spraying with extractions of two medicinal plants (*Glycyrrhiza glabra* L. and *Moringa oleifera* M.) and mycorrhizal symbiosis on vegetative growth, fruit yield, essential oil content and some chemical constituents of *Foeniculum vulgare* Mill plants.

The chemical and physical characteristics of experimental farm soil and irrigation water are shown in Table 1. Drip irrigation system was used.

Fennel seeds were kindly supplied from the National Research Center, Doki, Giza, Egypt. Seeds were sown directly in soil on 15$^{th}$ September during both seasons. The experimental unit area was 20 m$^2$ (20 m long x 1m wide). Every experimental unit contained three dripper lines with 20 m long.

The distance between lines was 50 cm and distance between plants in the same row was 30 cm. Five seeds were sown per hill, then thinned after three weeks to one plant/ hill. The other agricultural practices were carried out as recommended.

### Fertilizer and Medicinal Plant Extraction

Nitrogen fertilizer was applied at the rate of 100 kg. fad.$^{-1}$ of ammonium sulphate (20.5% N). It was added throw fertigation system during plant life. Ordinary calcium supper phosphate (15.5% $P_2O_5$) and potassium sulphate (48% $K_2O$) were added during soil preparation at the rates of 200 and 30 kg. fad.$^{-1}$, respectively. Mycorrhizal fungi were used in two treatments (un- inoculated and inoculated).

**Inoculation of AM fungi**

To increase the spore count, *i.e.*, inoculum potential in the soil to be used for open field experiments, mixed spores were collected from the rhizosphere of many plants which cultivated in the farm of Medicinal and Aromatic Plants, Fac. Environ. Agric. Sci., El-Arish, Suez Canal Univ., such as rosemary, chamomil, common sage, lavandar and aloe. Spores were then surface sterilized as described by Ravolanirina *et al.* (1987) and used for inoculation with onion (*Allium cepa* L.) as a recommended trap crop in an autoclaved soil for a period of four months to increase spore density. Heavily colonized adventitious roots of growing onion were also chopped into small fragments and mixed thoroughly with the associated rhizospheric soil (containing hyphae and spores) to form root balls. Spores and heavily colonized roots, in the form of root balls, were then transferred to the experimental field and incorporated into the soil at a depth of 2-3 cm below fennel plants according to Menge and Timmer (1982).

**Extraction and purification:**

From each rhizosphere soil sample, spores were extracted from 100 g soil aliquots using the technique of Gerdemann and Nicholson (1963).

**Identification**

In order to facilitate rapid determination of spore density, spore suspensions were filtered through 7 cm diameter Whitman filter paper No 1, marked with small squares (1:1cm) to examine spores. Before identification, spores were stained with Meltzer's reagent. After staining, spores were picked up with a micro-pipette and placed on a clean glass slide , then

**Table 1. Some initial chemical and physical characteristics of soil and chemical analysis of irrigation water**

| Parameter | Soil | | Irrigation water |
|---|---|---|---|
| | First season (2013-14) | Second season (2014-15) | |
| | Soluble ions meq.l$^{-1}$ (soil past extract) | | meq.l$^{-1}$ |
| $Ca^{++}$ | 3.03 | 3.09 | 18.12 |
| $Mg^{++}$ | 2.11 | 2.20 | 20.20 |
| $Na^{+}$ | 3.18 | 4.49 | 17.72 |
| $K^{+}$ | 0.48 | 0.31 | 0.25 |
| $Cl^{-}$ | 2.00 | 2.30 | 38.40 |
| $Co_3^{--}$ | 0.00 | 0.00 | 0.00 |
| $Hco_3^{-}$ | 2.00 | 2.40 | 6.25 |
| $So_4^{--}$ | 3.78 | 4.40 | 11.64 |
| EC (dsm$^{-1}$) | 0.68 | 0.91 | 5.65 |
| pH (1:2.5) | 8.10 | 8.20 | 6.70 |
| Organic carbon (g.kg$^{-1}$) | 0.93 | 1.22 | - |
| Organic matter (g.kg$^{-1}$) | 1.60 | 2.10 | - |
| Ca $CO_3$ (g.kg$^{-1}$) | 3.95 | 3.95 | - |
| | Particular size distribution (%) | | |
| Clay | 0.16 | 0.16 | - |
| Silt | 0.33 | 0.33 | - |
| Fine sand | 76.1 | 76.1 | - |
| Coarse sand | 18.71 | 18.71 | - |
| Soil texture | Sandy soil | Sandy soil | - |

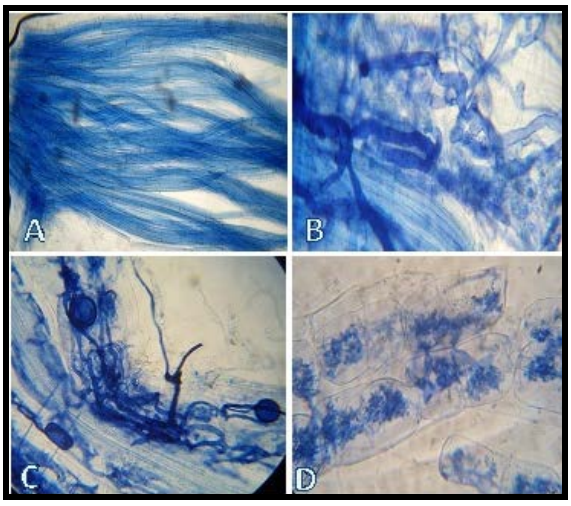


**Fig. 1. AM structures in fennel roots**

**A.** Roots without inoculation by AMF **B.** Hyphae within roots

**C.** Vesicles within roots **D.** Arbuscular within roots

examined to detect different morphological properties such as spore shape, longest dimension, wall thickness, and hyphae. Some hyphae may be attached to suspensor-like cells. Identification was carried out according to Gerdemann and Trappe (1974). Stained spores were then mounted in poly-vinyl alcohol-lactic acid-glycerol (PVLG) to make permanent slides.

**Determination of root colonization:**

To measure the rate of development of endomycorrhiza inside the roots of host plants (trap-crops), all root samples were prepared for staining then examined for the presence of hyphae or any AM structures according to (Philips and Hayman, 1970) as shown in Fig.1.

### Preparation of Aqueous Extract Solutions

Roots of licorice *(Glycyrrhiza glabra* L.) and leaves of moringa (*Moringa oleifera* M.) were collected from the farm of medicinal and aromatic plants, Fac. Environ. Agric. Sci, El-Arish, Suez Canal Univ. Roots and leaves of both plants were collected. The plant material was dried in an oven at 70° C for 48 hr. Then the dried material was ground in a grinder and passed through a 40 mesh screen. To prepare the extracts, 50 g of each ground plant material were macerated in 500 ml distilled water. Solutions were placed in orbital shaker at room temperature for 24 hr. The extracts were filtered using Whatman filter paper No.1 (Dayananda *et al*., 2010).

The obtained extracts were diluted in order to achieve the concentrations. Treatment concentrations of licorice were: control (distilled water), (L1) 20 $gl^{-1}$, (L2) 40 $gl^{-1}$ and (L3) 60 $gl^{-1}$) while moringa leaves extraction concentrations were: control (distilled water), 20 $gl^{-1}$ (M1), 40 $gl^{-1}$ (M2) and 60 $gl^{-1}$ (M3). Each aqueous extract was applied twice after one month of cultivation and after two weeks from the first application.

### Measurements

After 120 days from sowing and before harvesting, eight random plants from each treatment were used to determine the following growth criteria; plant height (cm), branch number, herb fresh and dry weights (g), flowering characteristics as number of umbels per plant and number of umbellets per umbel. Also yield components as fruit number per umbel, fruit yield per plant (g), fruit yield per fad., (kg) and volatile oil percentage were determined at the harvesting date ($4^{th}$ April during both seasons). Volatile oil was extracted from dried fruits by water distillation using Clevenger apparatus (Clevenger, 1928), then volatile oil percentage has been calculated.Herb contents (ppm) of nitrogen and phosphorus were determined according to AOAC (1975). Potassium content was determined in herb according to the method described by (Jackson, 1973).

### Experiment Design and Statistical Analysis

The complete randomized block design (CRBD) was used in this experiment with three replicates. All collected data were analyzed with analysis of variance (ANOVA) procedure using MSTAT- C Statistical Software Package (Michigan State University, 1983). Differences between means were compared by using Duncan's multiple range tests at 0.05 (Duncan, 1955).

## RESULTS AND DISCUSSION

### Effect of AM Fungi Inoculation Combined with Foliar Spray of Licorice and Moringa Aqueous Extract on Vegetative Growth and Flowering Characters of Fennel Plant

Data illustrated in Table 2 show the effect of AM Fungi inoculation combined with spraying of licorice and moringa aqueous extracts on vegetative growth and flowering characters of fennel plants during 2013 -2014 and 2014-2015 seasons. Data clear that inoculated fennel plants with AM fungi and sprayed with L2 (40 $gl^{-1}$) or L3 (60 $gl^{-1}$) aqueous extract of licorice roots recorded the highest significant values of all growth and flowering parameters without significant difference between both treatments in most cases in the first season.

**Table 2. Effect of AM Fungi inoculation combined with foliar spray with licorice and moringa aqueous extracts on vegetative growth and flowering of fennel plant during 2013/14 and 2014/15 seasons**

| Treatment | | Plant height (cm) | Branch No. | Herb fresh weight (g) | Herb dry weight (g) | No. of umbels /plant | No. of umbellets /umbel |
|---|---|---|---|---|---|---|---|
| AMF inoculation | Foliar spray ($gl^{-1}$) | | | | | | |
| **First season (2013-2014)** | | | | | | | |
| Inoculated | Control | 62.16 f | 3.33 ef | 37.58 f | 9.81 f | 5.66 hi | 7.66 de |
| | L1 | 83.16 c | 7.33 bc | 58.45 bc | 19.28 bc | 9.00 a-c | 9.66 ab |
| | L2 | 94.43 ab | 8.33 ab | 60.36 b | 20.84 ab | 9.33 ab | 10.00 ab |
| | L3 | 98.03 a | 9.33 a | 66.02 a | 22.69 a | 9.66 a | 10.33 a |
| | M1 | 80.83 c | 7.00 cd | 53.93 c-e | 16.78 cd | 7.33 d-g | 9.00 bc |
| | M2 | 90.56 b | 7.33 bc | 60.36 b | 18.86 bc | 7.66 d-f | 9.33 ab |
| | M3 | 93.96 ab | 7.66 bc | 61.57 ab | 20.52 ab | 8.33 b-d | 9.50 ab |
| Un-inoculated | Control | 53.33 g | 2.88 f | 34.85 f | 9.68 f | 5.33 i | 6.50 e |
| | L1 | 60.77 f | 4.33 e | 51.90 de | 14.90 de | 7.33 d-g | 7.33 de |
| | L2 | 73.83 d | 6.00 d | 54.90 cd | 17.74 bc | 7.66 d-f | 7.66 de |
| | L3 | 82.18 c | 7.33 bc | 58.56 bc | 19.37 bc | 8.00 c-e | 8.00 cd |
| | M1 | 57.60 fg | 6.00 d | 49.57 e | 13.89 e | 6.33 g-i | 7.00 de |
| | M2 | 60.33 f | 7.00 cd | 54.22 c-e | 17.25 cd | 6.66 f-h | 7.33 de |
| | M3 | 68.43 e | 7.00 cd | 55.35 cd | 17.65 c | 7.00 e-g | 7.66 de |
| **Second season (2014-2015)** | | | | | | | |
| Inoculated | Control | 64.16 e | 4.33 f | 39.48 g | 11.83 g | 6.66 cd | 8.66 b-d |
| | L1 | 85.16 c | 8.00 bc | 60.84 b-d | 20.82 b-d | 8.66 b | 8.7 7 bc |
| | L2 | 96.43 ab | 8.33 b | 62.29 bc | 22.29 bc | 9.33 b | 9.66 b |
| | L3 | 100.03 a | 9.70 a | 67.74 a | 24.88 a | 10.66 a | 11.33 a |
| | M1 | 82.90 c | 6.33 e | 57.50 c-e | 20.83 b-d | 8.33 bc | 8.66 b-d |
| | M2 | 92.60 b | 7.33 c-e | 62.31 bc | 21.66 b-d | 9.00 b | 9.00 bc |
| | M3 | 95.93 ab | 7.66 b-d | 64.98 ab | 22.70 bc | 9.33 b | 9.66 b |
| Un-inoculated | Control | 58.33 f | 3.40 g | 36.95 g | 11.79 g | 6.33 d | 6.66 e |
| | L1 | 72.80 d | 6.33 e | 53.35 ef | 17.91 e | 7.33 b-d | 7.33 de |
| | L2 | 85.30 c | 7.00 de | 56.20 d-f | 19.73 de | 7.66 bc | 7.77 c-e |
| | L3 | 86.96 c | 7.33 c-e | 57.12 c-e | 20.41 cd | 8.22 bc | 8.00 cd |
| | M1 | 66.36 e | 6.50 e | 51.59 f | 15.67 f | 7.00 cd | 7.33 de |
| | M2 | 69.30 de | 6.70 de | 59.16 cd | 19.23 de | 7.33 b-d | 8.00 cd |
| | M3 | 73.46 d | 7.04 c-e | 59.19 cd | 19.95 de | 7.66 bc | 8.20 cd |

Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability

The same trend was observed in the second season, but only inoculated plants sprayed with 60 $gl^{-1}$ licorice extract (L3) gave the highest significant growth and flowering values; *i.e.*, (plant height, branch number, herb fresh and dry weights, number of umbels per plant and number of umbellets per umbel (100.03 cm, 9.70, 67.74 g, 24.88 g, 10.66 ; 11.33, respectively).

These results were in harmony with those found by El-Jawary (2002) on sweet pepper, Fayad (2005) on cucumber, Jibouri *et al.* (2005) on sweet pepper, Husain and El-Rekaby (2006) on cucumber, Kamal and Ghanem (2012) on snap bean, Nasser *et al.* (2014) on fenugreek and Hassan and Abd El-Samee (2015) on roselle. They reported that foliar spraying with licorice extract has a favorable biological effect on fresh and dry weights of plants, flowering, total yield and fruits quality of above mentioned crops.

This increase may be because of AMF can benefit plants by stimulating the production of growth regulating substances, increasing photosynthesis, improving osmotic adjustment under drought and salinity stresses and increasing resistance to pests and soil borne diseases (Al-Karaki, 2006).

## Effect of AM Fungi Inoculation Combined with Foliar Spray of Licorice and Moringa Aqueous Extracts on Yield Parameters of Fennel Plant

Data presented in Table 3 show the effect of AM Fungi inoculation combined with spraying of licorice and moringa aqueous extracts on yield parameters of fennel plants during 2013/ 14 and 2014/15 seasons. Data clear that inoculating fennel plants with AM Fungi combined with L3 aqueous extract of licorice roots resulted in a significant increase in fruit No./umbel, fruit yield / plant and fruit yield/fad., (12.66, 17.51g and 490.28 kg, respectively) during the first season. The same trend was observed in the second season (13.00, 18.46 g and 516.88 kg, respectively).

The role of licorice aqueous extract as foliar spray may be due to that licorice roots extraction contains mainly glycyrrhizin, flavonoids, reducing and non-reducing sugars, plant gums, resins, essential oils, inorganic salts and low levels of nitrogenous constituents such as proteins, individual amino acids and nucleic acids (Isbruker and Burdock, 2006).

On the other hand, volatile oil percentage data clear that there were no significant differences between AM fungi inoculation and un- inoculated on this regard.

## Effect of AM Fungi Inoculation Combined with Foliar Spray Licorice and Moringa Aqueous Extracts on Chemical Constituents of Fennel Plant

Data in Table 4 show that nitrogen, phosphorus and potassium contents of the fennel herb were significantly affected by all treatments in both seasons. Fennel plants inoculated with AM Fungi combined with M3 aqueous extract of moringa leaves gave the highest herb contents of nitrogen (0.374 ppm in the first season and 0.385 ppm in the second season), phosphorus (0.275 ppm in the first and 0.283 ppm in the second season) and potassium (148.49 ppm in the first and 156.13 ppm in the second season).

The increase of herb content of nitrogen, phosphorus and potassium may be due to moringa leaf extract is a rich source of amino acids, potassium, calcium, iron, vitamin E, ascorbates, phenolic compounds and growth regulating hormones like zeatin (Makkar and Becker, 1996 ; Nagar *et al*., 2006). Also, AM fungi Improved productivity of plants, that was attributed to enhanced uptake of immobile nutrients such as phosphorus, zinc, nitrogen and copper. AM fungi can be integrated in soil management to achieve low-cost sustainable agricultural systems (Hooker and Blackke, 1995).

**Table 3. Effect of AM Fungi inoculation combined with foliar spray with licorice and moringa aqueous extracts on yield parameters of fennel plant during 2013/14 and 2014/15 seasons**

| Treatment | | Fruit No. / umbel | Fruit yield / plant (g) | Fruit yield / fad. (kg) | Volatile oil (%) |
|---|---|---|---|---|---|
| AMF inoculation | Foliar spray ($gl^{-1}$) | | | | |
| | | **First season 2013/14** | | | |
| **Inoculated** | **Control** | 8.66 ef | 10.32 ef | 288.96 ef | 1.30 cd |
| | **L1** | 10.00 cd | 12.29 c | 344.12 c | 1.40 b-d |
| | **L2** | 11.66 bc | 13.53 b | 378.84 b | 1.60 a-c |
| | **L3** | 12.66 a | 17.51 a | 490.28 a | 1.80 a |
| | **M1** | 9.66 c-e | 11.32 d | 316.96 d | 1.30 cd |
| | **M2** | 10.00 cd | 12.41 c | 347.48 c | 1.50 a-d |
| | **M3** | 10.66 cd | 13.41 b | 375.48 b | 1.60 a-c |
| **Un-inoculated** | **Control** | 7.33 g | 8.83 g | 247.24 f | 1.20 d |
| | **L1** | 8.40 e-g | 10.14 f | 283.92 f | 1.30 cd |
| | **L2** | 9.33 d-f | 11.15 de | 312.20 de | 1.50 a-d |
| | **L3** | 10.00 cd | 12.57 bc | 351.96 bc | 1.72 a |
| | **M1** | 8.33 fg | 9.32 fg | 260..96 f | 1.20 d |
| | **M2** | 8.66 ef | 9.99 f | 279.72 f | 1.40 b-d |
| | **M3** | 8.70 ef | 10.20 ef | 285.60 ef | 1.60 a-c |
| | | **Second season 2014/15** | | | |
| **Inoculated** | **Control** | 9.00 e-g | 11.63 d-f | 325.64 f | 1.40 bc |
| | **L1** | 10.33 b-e | 13.05 cd | 365.40 d | 1.50 a-c |
| | **L2** | 11.66 b | 13.73 bc | 384.44 c | 1.70 ab |
| | **L3** | 13.00 a | 18.46 a | 516.88 a | 1.83 a |
| | **M1** | 10.66 b-d | 12.76 c-e | 357.28 e | 1.40 bc |
| | **M2** | 11.00 b-d | 13.03 cd | 364.84 d | 1.60 a-c |
| | **M3** | 11.33 bc | 14.74 b | 412.72 b | 1.80 a |
| **Un-inoculated** | **Control** | 7.33 h | 9.25 g | 259.00 j | 1.33 bc |
| | **L1** | 8.66 fg | 10.90 f | 305.20 h | 1.40 bc |
| | **L2** | 9.66 d-g | 12.85 cd | 359.80 e | 1.60 a-c |
| | **L3** | 10.00 c-f | 13.12 cd | 367.36 d | 1.80 a |
| | **M1** | 8.33 gh | 10.67 f | 298.76 i | 1.30 c |
| | **M2** | 9.66 d-g | 11.35 ef | 317.80 g | 1.50 a-c |
| | **M3** | 9.80 d-f | 11.56 d-f | 323.68 f | 1.70 ab |

Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range tests at 5% level of probability.

**Table 4. Effect of AM Fungi inoculation combined with licorice and moringa aqueous extracts on chemical constituents of fennel herb during 2013/14 and 2014/15 seasons**

| Treatment | | N (ppm) | P (ppm) | K (ppm) |
|---|---|---|---|---|
| AMF inoculation | Foliar spray ($gl^{-1}$) | | | |
| | | **First season (2013-2014)** | | |
| Inoculated | Control | 0.110 m | 0.112 i | 98.08 j |
| | L1 | 0.201 h | 0.122 h | 101.75 i |
| | L2 | 0.225 f | 0.133 g | 119.17 f |
| | L3 | 0.234 e | 0.156 f | 127.42 d |
| | M1 | 0.249 d | 0.203 d | 136.58 c |
| | M2 | 0.338 b | 0.242 b | 140.25 b |
| | M3 | 0.374 a | 0.275 a | 148.49 a |
| Un-inoculated | Control | 0.105 n | 0.102 j | 62.33 n |
| | L1 | 0.166 l | 0.107 ij | 71.33 m |
| | L2 | 0.178 k | 0.120 h | 87.45 l |
| | L3 | 0.187 j | 0.187 e | 93.13 k |
| | M1 | 0.195 i | 0.190 e | 108.17 h |
| | M2 | 0.211g | 0.203 d | 111.33 g |
| | M3 | 0.287 c | 0.210 c | 119.31 e |
| | | **Second season (2014-2015)** | | |
| Inoculated | Control | 0.125 l | 0.121 i | 102.22 j |
| | L1 | 0.211 h | 0.130 h | 112.33 i |
| | L2 | 0.233 f | 0.141 g | 130.33 e |
| | L3 | 0.242 e | 0.164 f | 136.44 d |
| | M1 | 0.260 d | 0.212 d | 145.12 c |
| | M2 | 0.342 b | 0.250 b | 151.33 b |
| | M3 | 0.385 a | 0.283 a | 156.13 a |
| Un-inoculated | Control | 0.112 m | 0.110 j | 72.22 n |
| | L1 | 0.174 k | 0.118 i | 82.13 m |
| | L2 | 0.190 j | 0.121 i | 95.30 l |
| | L3 | 0.199 i | 0.199 e | 101.20 k |
| | M1 | 0.201 i | 0.203 e | 116.33 i |
| | M2 | 0.220 g | 0.210 d | 120.45 g |
| | M3 | 0.295 c | 0.221 c | 129.55 f |

Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability.

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## تأثير التلقيح بالميكروهيزا والرش الورقى بمستخلصات بعض النباتات على نمو وإنتاجية نبات الشمر

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أجريت هذه الدراسة بالمزرعة التجريبية لكلية العلوم الزراعية البيئية بالعريش - جامعة قناة السويس خلال الموسمين المتتاليين ٢٠١٣/٢٠١٤ و ٢٠١٤/٢٠١٥ لدراسة تأثير التلقيح بالميكروهيزا والرش الورقى بالمستخلصات المائية لبعض النباتات على نمو وإنتاجية نبات الشمر، حيث تم الرش بالمستخلص المائى لكل من جذور العرقسوس بتركيزات صفر، ٢٠، ٤٠ ، ٦٠ جم/لتر وأوراق المورينجا بتركيزات صفر ، ٢٠ ، ٤٠ ، ٦٠ جم/لتر وذلك برشها مرتين: الأولى بعد شهر من الزراعة، والثانية بعد اسبوعين من الأولى، وقد أظهرت النتائج المتحصل عليها أن نباتات الشمر التي تم تلقيحها بالميكروهيزا ورشها بتركيز ٤٠ أو ٦٠ جم/لتر بالمستخلص المائى لجذور العرقسوس سجلت أعلى القيم المعنوية لصفات النمو والتزهير بدون أى اختلافات معنوية بين تلك المعاملتين فى معظم الحالات فى الموسم الأول، وقد سجل نفس الاتجاه فى الموسم الثانى فيما عدا النباتات الملقحة بالميكروهيزا والمعاملة بالرش بالمستخلص المائى لجذور العرقسوس بتركيز ٦٠ جم/لتر والتي أعطت أعلى القيم المعنوية لصفات النمو والتزهير على الترتيب التالى (ارتفاع النبات (سم)، وعدد الأفرع، الوزن الطازج والجاف للعشب (جرام)، وعدد النورات لكل نبات، وعدد النيرات لكل نورة) (١٠٠.٠٣ سم، ٩.٧٠، ٦٧.٧٤ جم، ٢٤.٨٨ جم، ١٠.٦٦ و ١١.٣٣ على التوالى)، أيضا أدى التلقيح بالميكروهيزا مع الرش بالمستخلص المائى لجذور العرقسوس بتركيز ٦٠ جم/لتر إلى زيادة معنوية فى عدد الثمار/ نورة، ومحصول الثمار/نبات (جم)، ومحصول الثمار/ فدان (كجم) (١٢.٦٦، ١٧.٥ جم ، ٤٩٠.٢٨ كجم على التوالى) فى الموسم الأول و(١٣، ١٨.٤٦ جم ، ٥١٦.٨٨ كجم على التوالى فى الموسم الثانى، فى حين أدى تلقيح نبات الشمر بالميكروهيزا مع الرش بالمستخلص المائى لأوراق المورينجا بتركيز ٦٠ جم/لتر إلى الحصول على أعلى محتوى للعشب من النيتروجين ( ٠.٣٧٤، و ٠.٣٨٥ جزء فى المليون)، والفسفور (٠.٢٧٥ جزء فى المليون و٠.٢٨٣ جزء فى المليون) والبوتاسيوم (١٤٨.٤٩ و ١٥٦.١٣ جزء فى المليون) لكلا الموسمسن على التوالى.

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